A sequence of volcanic flank collapse and tsunami event on 22 December 2018 at Anak Krakatau volcano, Indonesia

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Tsunamis were generated at the Sunda Strait, Indonesia, on 22 December 2018 (~21:00 local time), and a disaster (>430 victims) occurred along the coastal area close to Krakatau. As it became clear that the southwest side of Anak Krakatau Island that has continued eruptive activity in recent years had collapsed, the tsunamis are thought to have occurred with the edifice collapse of this volcanic island (PVMBG, 2018). The volume of collapsed material, the process of the collapse event, the tsunami generation and propagation processes, and the relationship between these and the eruption activity are still unclear. Therefore we investigated the sequence of the eruption and tsunami event at Anak Krakatau on 22 Dec 2018 based on satellite images and tsunami numerical simulation. Infrared data of Himawari-8 showed that thermal anomaly has continued since the middle of June 2018 but no specific anomaly signals were detected before the collapse-tsunami event. Then the data showed that the eruptive plume occurred from ~13:50 UTC on 22 December 2018. This time was 40-70 min before tsunami arrival at the coastal areas around Sunda Strait (~14:30-15:00 UTC). The first eruptive plume developed after ~13:50 but soon declined within an hour, then the second eruptive plume developed from ~15:20. It became much higher than the first one and sustained in the next couple of days. Numerical simulation of tsunami and volcanic flank collapse was carried out with the two-layer shallow water model based on non-linear long wave theory that has been developed for the tsunamis generated by gravity flows (pyroclastic flows, debris avalanche, etc.) flowing into the water. It was solved with a finite difference method. Bathymetry data is the same as that used in Maeno and Imamura (2011). The bottom friction coefficient of the gravity current was set to be 0.01 for subaerial condition and 0.06-0.12 for submarine condition. The interfacial drag coefficients between the gravity current and seawater were set to be 0.2. The four cases with different collapsed volumes (0.16, 0.21, 0.26, 0.31 km^3) were examined. The computed tsunami waveforms were compared with tide gauge records (PVMBG, 2018) at representative locations. The most likely initial condition to explain the tide gauge records was the initial collapse volume of 0.21-0.26 km^3. Other parameters don't significantly affect the results. Numerical results also showed that, for all cases, the maximum wave height (>3 m) in the SW coast of Java became higher than other areas. This tendency is consistent with the observational records that the SW coast of Java was more heavily damaged by tsunamis. This is probably because the direction of the collapse was southwestward but the direction of tsunami propagation was gradually changed from SW to S-SE by the effect of bathymetry. We also calculated tsunami travel times and estimated the occurrence time at the source, comparing with tsunami arrival times recorded in the tide gauges. As a result it seems that the tsunamis were caused by 13:54±2 min. We conclude that the collapse occurred almost simultaneously with the small eruption from ~13:50 UTC then followed by the main sustained eruption from ~15:20. In order to determine the timing and mechanism of the collapse event more precisely, it is necessary to further evaluate initial conditions and models as well as to compare with other geological and geophysical data.

Keywords: volcanic flank collapse, tsunami, Anak Krakatau

